

# On the requirements of waveforms and systems for use in joint communications and radar operation

Jonathan Peck (SRC, Inc.)

Michael Zatman (SAZE Technologies)

Mark Perillo (SRC, Inc.)

“The views expressed are those of the author  
and do not reflect the official policy or  
position of the Department of Defense or the  
U.S. Government”

Distribution Statement “A” (Approved for Public Release, Distribution Unlimited)





# Agenda

## High Level Technical Overview

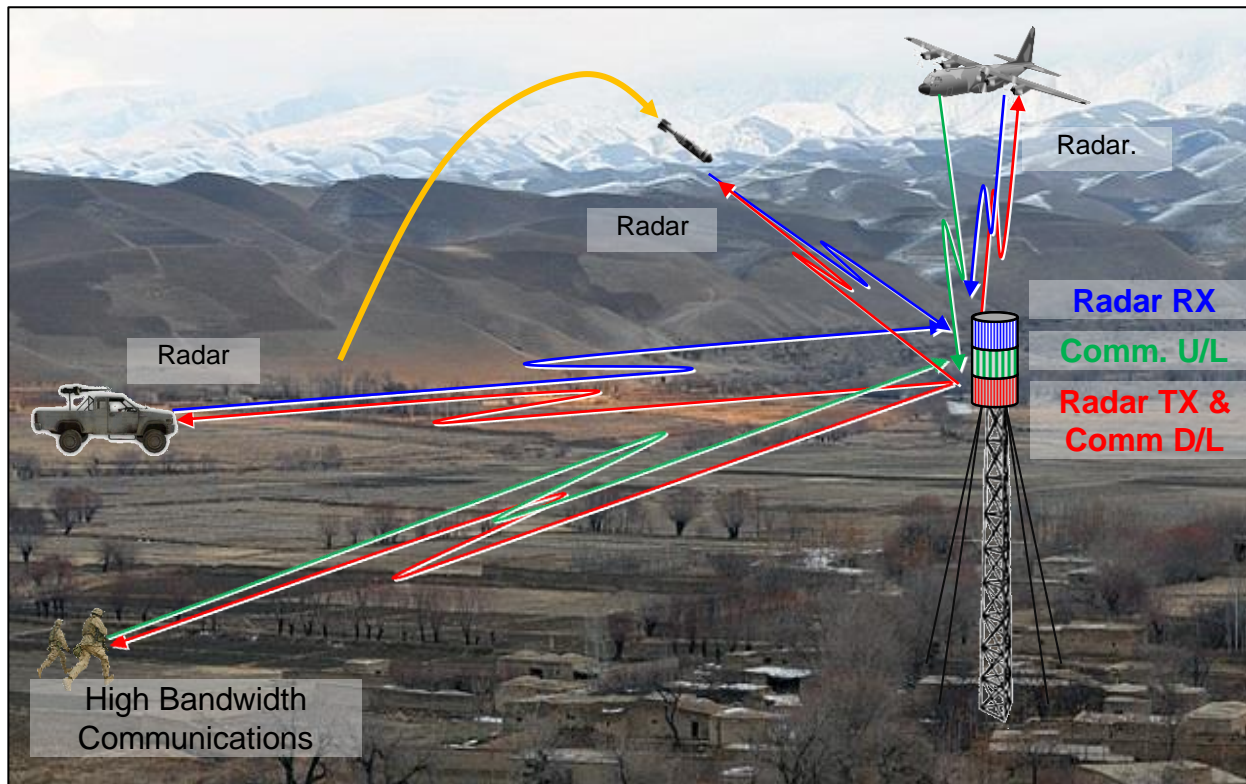
- COMMDAR – The joint communications and radar system
- Waveform
  - Requirements for radar
  - Requirements for communications
  - Common requirements
- MIMO
  - Communications
  - Radar

Distribution Statement "A" (Approved for Public Release, Distribution Unlimited)



# COMMDAR System Overview

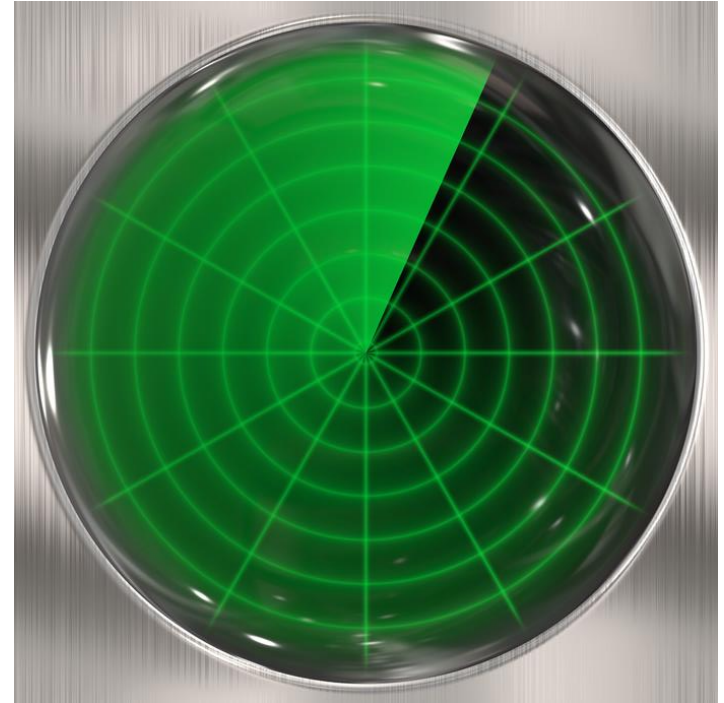
- Fixed site COMMDAR installation
- Joint radar and downlink communication waveform
- Uplink communication on separate frequency (FDD)





# Waveform Requirements for Radar

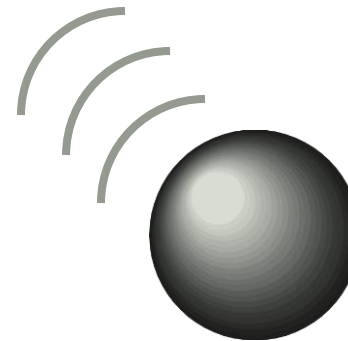
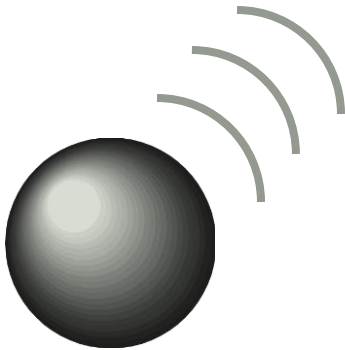
- Spectral Leakage
  - Computational Complexity
  - Range/Doppler Sidelobes
  - Clutter Suppression
  - Energy on Target
  - Range Resolution
  - Doppler Resolution
  - No Waveform Ambiguities
- SINR





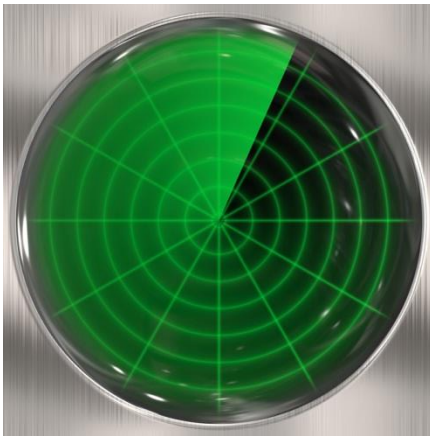
# Waveform Requirements for Comms

- Spectral Leakage
- Computational Complexity
- Data Rate and Spectral Efficiency
- Synchronization/Training Required
- Network Control Required
- Ability to Meet Quality of Service Requirements

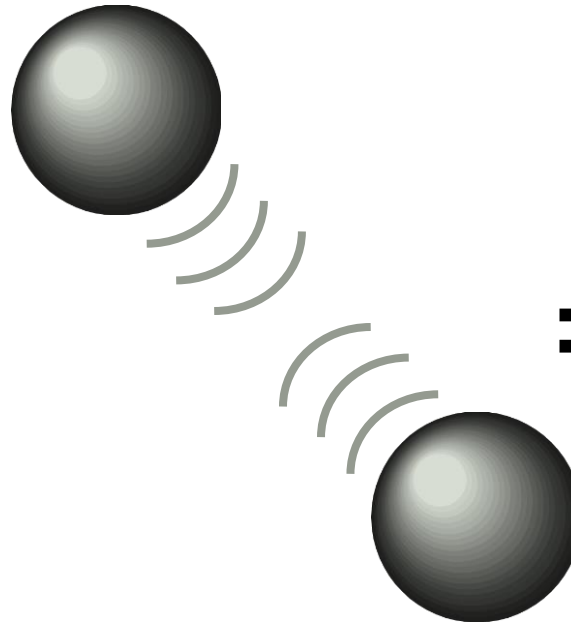




# COMMDAR = Communications & Radar



+



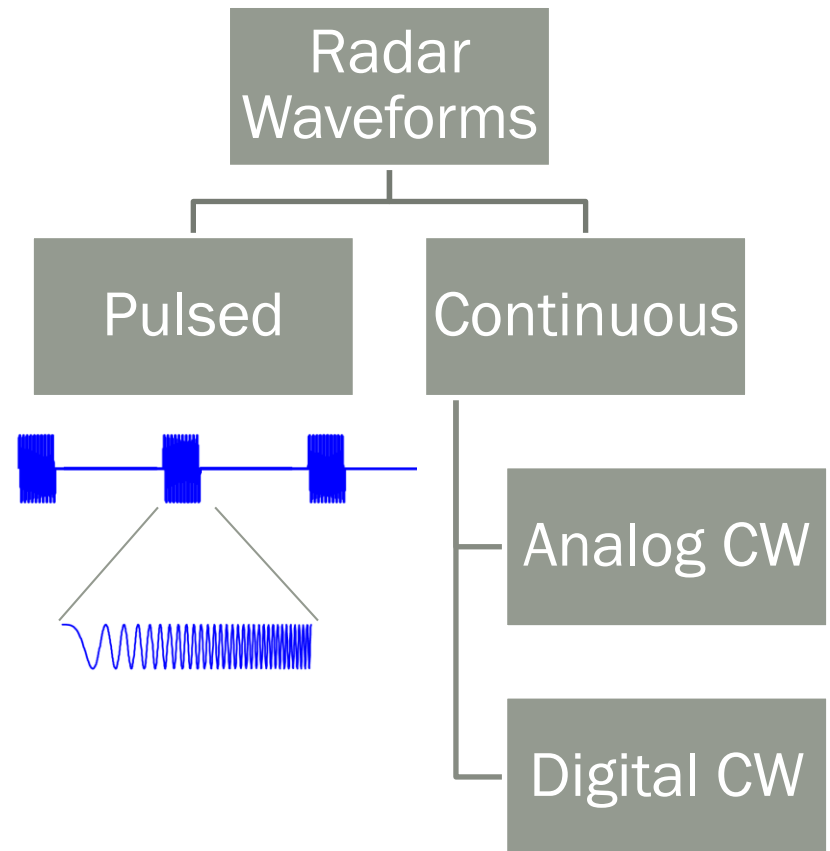
=





# Joint Waveform Requirements

- Spectral leakage
- Computational complexity
- Peak to average power ratio





# Fundamental Differences

- Radar is typically SNR limited
- Communications either SNR or bandwidth limited
- Radar waveforms are typically pulsed
- Communications are typically continuous

**Communications:**

$$C = B \log(1 + SNR)$$

Only Comms has  
bandwidth

**Radar:**

$$R_{max} = \sqrt[4]{\frac{P_{avg} G_t A_r \sigma T_{int}}{(4\pi)^2 SNR N_0}}$$

Both have SNR





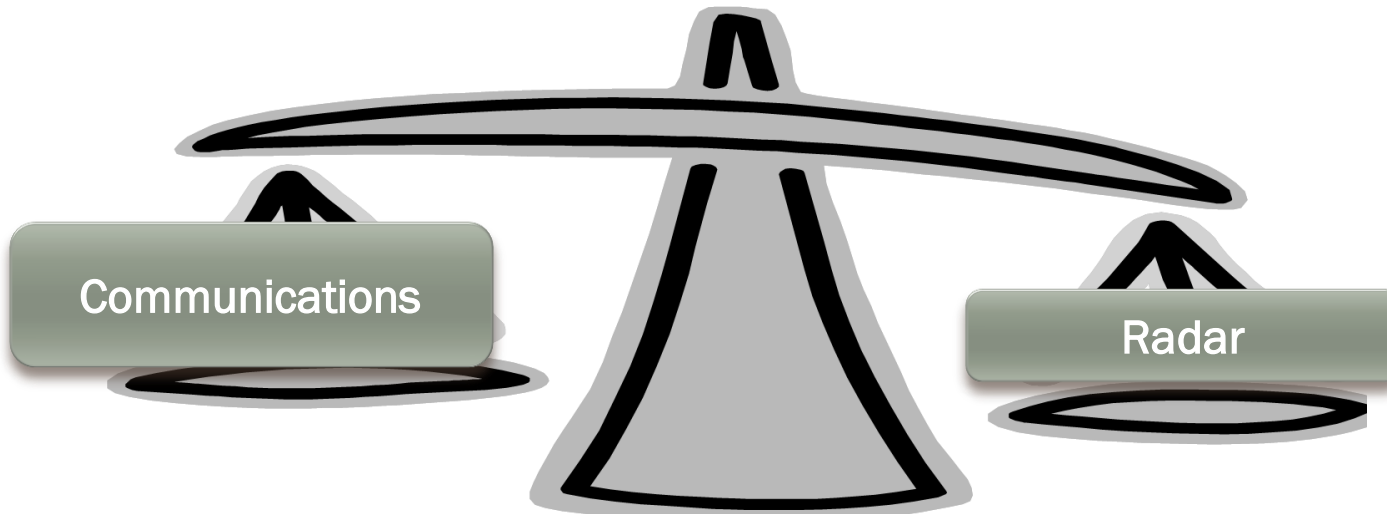
# Waveform Requirements Tradeoff

Waveform Degrees of Freedom	Communications Metrics						Radar Metrics					
COMMDAR Choice												

- Analyze multiple waveforms
  - Pulsed vs. continuous
  - Waveform modulation: OFDM, DSSS, Single Carrier,...
  - Multiuser access: TDMA, CDMA,...
  - MIMO
  - Etc.



# Conflicts in Conventional Waveforms



## Maximizes data rate

- Phase and amplitude modulation
- Tolerant of high PAPR
- High modulation order when SNR allows

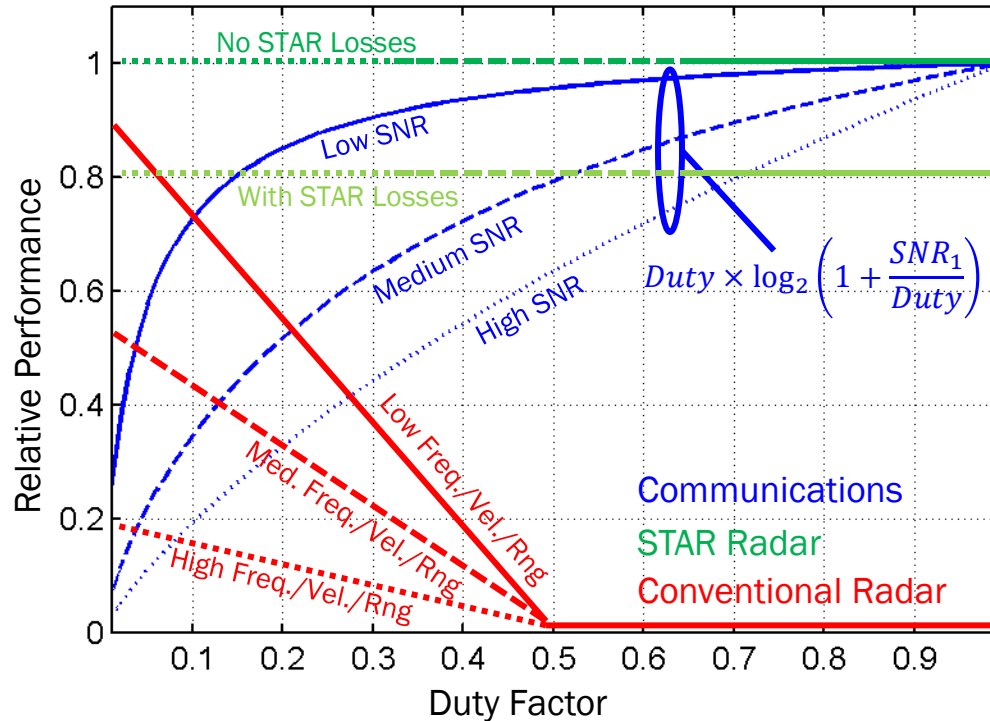
## Maximizes SNR/Power

- Phase or frequency modulation
- Intolerant of high PAPR
- Typically low modulation order or analog modulation

Focus on maximizing radar energy on target



# 100% Duty Factor is Good for Both



- Pulsed waveform radar performance degrades with increasing duty factor while comms. performance degrades with decreasing duty.
- Simultaneous transmit & receive (STAR) enables high-duty factors to work well for radar. COMMDAR goal is 100% duty factor waveform.
- Both continuous and pulsed waveforms will be compared.



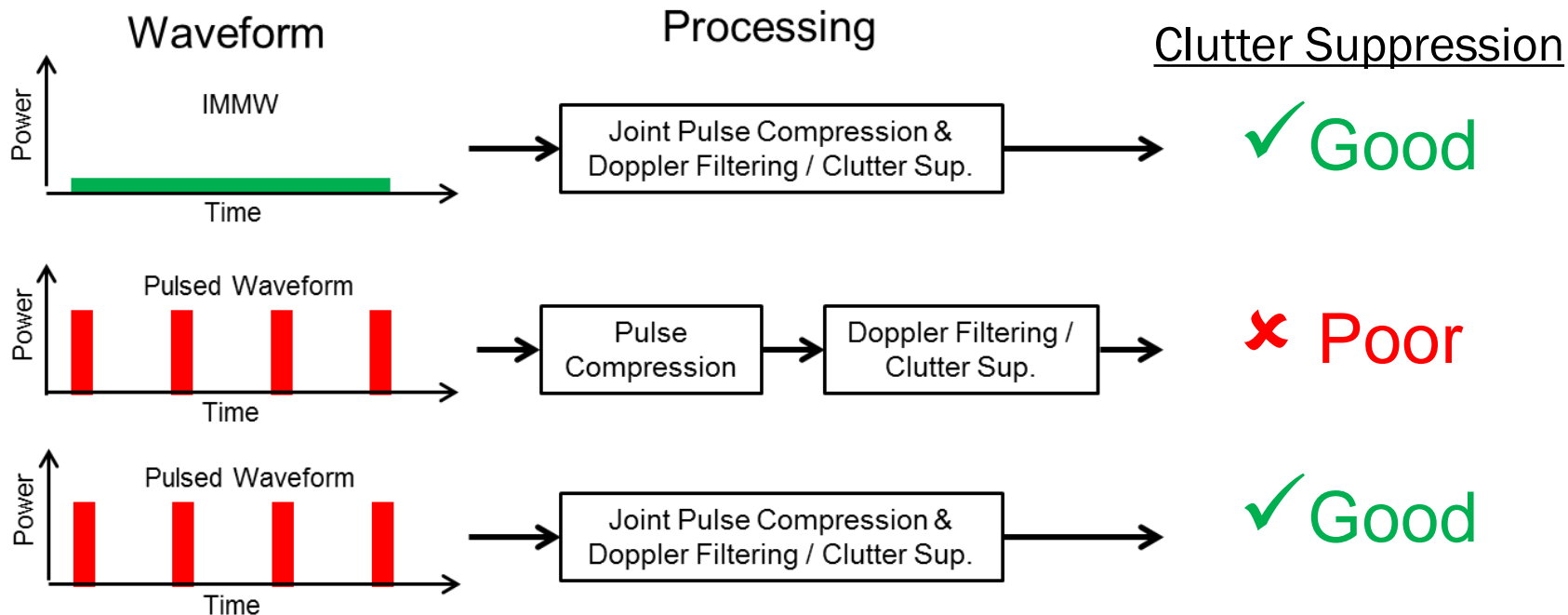
# Computational Complexity

## Radar

- Filtering out interference

## Communications

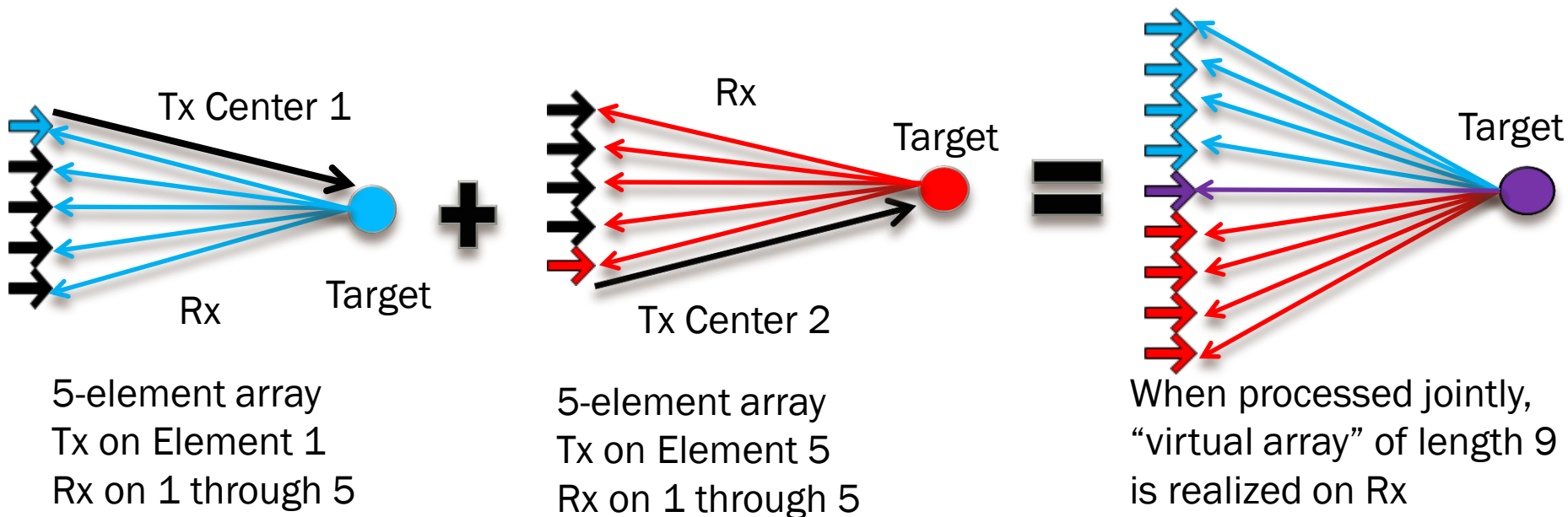
- Channel equalization





# MIMO Radar

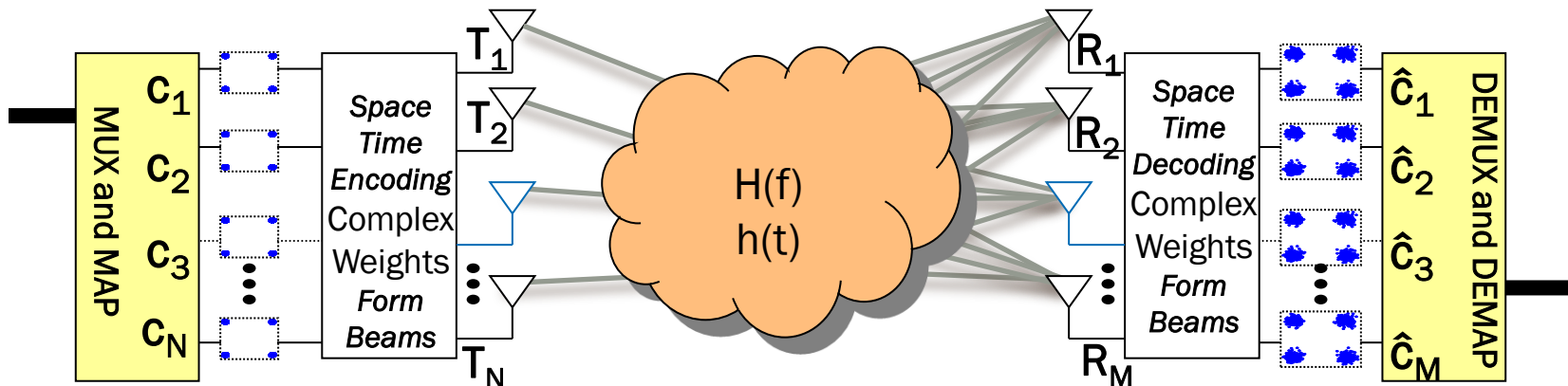
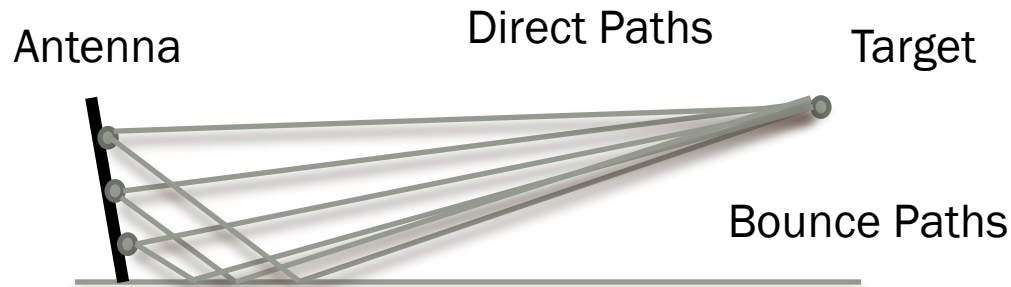
- Radar MIMO is a technique to achieve improved performance from a phased array
- Benefits of MIMO radar:
  - Improved angular resolution and accuracy
  - Reduced physical size (and cost) for a given beamwidth
  - The most severe multi-path fades are reduced due to phase diversity





# MIMO Requirements

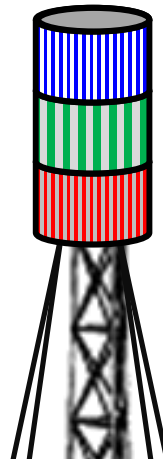
- MIMO COMMS → High rank channel matrix
  - Allows for high correlation between waveforms
- MIMO RADAR → Lower rank channel matrix
  - Requires low cross-correlation properties in space-time codes





# Summary

- COMMDAR: Joint downlink communications and radar waveform
- Waveform requirements
  - Fundamental differences
  - What is good for both radar and communications → 100% duty factor
  - Peak to average power ratio is more critical for radar operations
- MIMO
  - MIMO COMMS → High rank channel matrix
  - MIMO RADAR → Lower rank channel matrix





# Questions?